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ABSTRACT

The relationship between enrollment and costs at colleges and universities is examined. The question of whether large size provides economy of scale for operating and the manner in which complexity, size, costs, and enrollment interrelate are addressed. Data were analyzed from a national sample of 1,347 four-year universities, with an enrollment between 200 and 40,000 students, that provided adequate information on the 1975 Higher Education General Information Survey. The path analysis of the study model revealed that size does have a direct effect on cost per student; however, the amount is small and is eclipsed by the far greater effect of changes in the staffing ratio and by changes in curricular complexity. The staffing ratio has the greatest direct effect on costs. These staffing ratios, however, appear to be independent of other factors in the model, essentially resulting from external influences. (SW)

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SIZE AND EFFICIENCY

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Abstract

While it has been long assumed that it takes some optimum size in order to obtain a sufficient critical mass to have an economy of scale operation, little substantive study has been devoted to the topic. This paper looks at the relationship between enrollment and costs at colleges and universities. The question under study is whether large size provides economy of scale for operating. The question, unfortunately, is masked by the complexity of an institution. The manner in which complexity, size, costs, and enrollment interrelate is the substance of this paper. The findings suggest that curricula and complexity have an exceedingly important bearing on per student costs.

SIZE AND EFFICIENCY

The costs of colleges and universities continue to be a topic of great concern on local campuses and in legislative and executive agencies of state and federal government. Large or small, complex or single purpose, colleges and universities always have greater need for expenditures than they have money to spend. Little wonder that many state-level organizations have sought procedures to allocate funds for public institutions. Formula funding, which allocates resources according to certain assumptions and rules which vary by state tends to be widely copied by state agencies (Drewry and Sellers, 1977), has been embraced by many states as a way to proceed. A quiver of dread, therefore, should have passed through the educational community in Virginia and neighboring states when the Virginia House of Delegates passed a resolution in February, 1978, which requested the State Council of Higher Education for Virginia, in the preparation of budget guidelines, to consider faculty/student ratios (and hence funding) based on the size of institutions of higher education. Proponents of the resolution made the assumption that economies of scale exist in which costs decrease as size increases. If size is to become a variable in funding, then it is appropriate to see what effect size has on student costs and to ascertain whether it is size or some other factor, such as number of curricular offerings, which dictate costs.

Review of the Literature

In economics the concept of economies of scale states that one can expect to obtain lower unit costs with larger facilities. The idea is that greater technical advantages accrue by specialization of inputs or activities, and because of improved management. It should also be recalled, however, that the same theory embraces diseconomies of scale. Diseconomy emerges as the cost per unit increases with size of plant or production. The best profit occurs when one minimizes the average cost of producing the unit (Peterson, pp. 80-81).

Regardless of size, colleges usually maintain a minimal administrative unit, a library staff, and a buildings and grounds organization. As enrollment increases, accompanying costs increase, but initially at a slower rate than enrollment (Hawley, Boland, and Boland, 1965; Corrallo and O'Conor, 1973; and Scales, 1969). One might theorize that the proportion of expenditures for administrative and associated costs while growing would be at a smaller magnitude than other costs such as those associated with the salaries needed for the growing number of faculty to teach the new students. Studies of economies of scale by the Carnegie Commission of Higher Education (1972) and Jordan (1965) indicate that such a theory is correct. These two sources contend that as enrollment increases, per capita expenditures for both administration and libraries decrease, thus creating economies in the operation of larger community colleges. It should be obvious that institutions which are large enough to establish centralized administrative units, secretarial pools, or other cost-saving structures can reduce the proportion of expenditures for such functional areas. A report of the Carnegie Commission (1970) suggests this optimum to be in the vicinity of 2,000 to 5,000 students. From economic theory, however, one should recall that while expenses per unit produced initially decline with each increase in number produced, this condition reverses at some point and thereafter costs increase per number produced.

Results from other studies, however, do not support the economy of scale articles cited above. A recent analysis of 22 public senior institutions on 6 expenditure categories led to the finding that no economies of scale in expenditures per FTE student existed (Broomall, Mahan, McLaughlin, and Patton, 1978). A possible explanation comes from the work of Hawley, Boland, and Boland (1965) who surveyed four-year institutions in 1961 and found that enrollment size was highly correlated (r=.9[illegible]) with expenditures for instruction. They found that as size increased, so did organizational complexity (as measured by number of administrative levels in the governance structure and by the number of departments and programs offered within the colleges) and centralization of control (as observed in standardization and uniformity of program structures).

Blau (1974) reports on three research studies, sponsored by the National Science Foundation, which analyze the relationships between characteristics of organizations. He reports that in simple organizations operating costs tend to drop significantly as the size of the organization increases. As organizations grow in size, however, they tend to become more complex. Blau (1974, p. 238) states: "Simple agencies exhibit an economy of scale, whereas complex ones do not. Whether the division of labor or professionalization is taken as the indication of structural complexity, larger organizations tend to operate at lower costs than smaller ones if their structure is simple, but not if it is complex." These three findings suggest that large size brings complexity and complexity consumes any savings which might be generated by size.

Among the unresolved issues in the literature, therefore, are these:

(1) Can Blau's findings be replicated using a broad national sample?

(2) Given that complexity remains constant, what is the effect of student enrollment on costs?

The actual issue is what influences costs and to what degree. The resolution of this concern for complexity versus economy of scale can be rephrased as follows: what factors have an effect on unit cost in higher education?

Methodology

The sample selected for this survey was comprised of 1,347 public four-year colleges and universities. In order to obtain this number, data were initially collected on all institutions which submitted to the U.S. Office of Education the Higher Education General Information Survey (HEGIS) reports for 1975-76:

2300-1	Institutional Characteristics of Colleges and Universities
2300-2.1	Degrees and Other Formal Awards Conferred
2300-2.3	Opening Fall Enrollment in Higher Education
2300-3	Salaries, Tenure, and Fringe Benefits of Full-Time Instructional Faculty
2300-4	Financial Statistics of Institutions of Higher Education for the Fiscal Year

Institutions were then purged from the study if they fell into any of the following categories:

a. Multi-campus institutions (when the overall figures might mask deviations by campus)

b. Federally-operated institutions (for example, U.S. Military Academy)

c. Medical schools and theological seminaries

d. Institutions with enrollments less than 200 or more than 40,000

e. Apparent anomalies in the data (Union Experimenting College and University of Ohio)

f. Institutions in which the highest degree offering was less than a baccalaureate or greater than a doctorate

g. Institutions which did not award a degree in at least one curriculum at either the bachelor's, master's or doctoral level

h. Institutions with fewer than 5 faculty

The method of analysis selected for the review of the data was path analysis (Alwin and Hauser, 1975). A path analysis permits the interpretation of linear relationships within a set of variables, assuming a causal order among them and that the pattern of relationships among them is causally closed. In a set of variables, $X_1, X_2, X_3, \ldots, X_n$, X_i can be said to be a cause of X_j if X_j can be changed by manipulating X_i. This does not imply that all the other variables must remain unchanged. Causal order exists between X_i and X_j if it is assumed that X_i may affect X_j but that X_j cannot affect X_i. This is graphically represented by $X_i \xrightarrow{P_{ji}} X_j$ and algebraically by $X_j = P_{ji}X_i$. In addition to assuming that the correlational analyses used are correctly focused on the variable to be studied, three other terms are used in path analysis:

a. Association--the total linear relationship between measures.

b. Total effect--the total change in X_j which results from a change in X_i.

c. Direct effect—the change in X_j which results from a change in X_i with intervening variables held constant.

In this study these measures were computed with regression techniques and standardized variables ($\mu=0$, $\sigma=1$) as recommended by Alwin and Hauser (1975).

The important issue, for purposes of this analysis, was to determine what variables influence costs. By regression techniques a linear model is analyzed to explain which variables contribute to costs.

In modeling, such as that undertaken in this study, a starting point is necessary and the faculty to student ratio appeared best suited for that purpose. This selection was based on the belief that faculty to student ratios have in recent years been determined primarily as a result of dollars available to operate a university. The influx of students in the post-World War II decades required more faculty to be hired, and the increased numbers of faculty with their myriad specialities encouraged more curricula and degree offerings. A desire to attract more students might on occasion work independently to encourage a new major or a new degree offering. Throughout this growth the ratio of faculty to students stayed relatively constant. Complexity developed from the addition of majors and degree fields (Hawley, Boland, and Boland, 1965). After all, each new degree or major usually brought unique courses for students selecting it. Degree offerings produce unique courses which cause complex processes which work against economies of scale. The rationale for starting with a staffing ratio, therefore, is that these ratios were sensitive to external forces.

The path analysis used in this study contained six variables:

X_f Ratio of faculty to student enrollment

X_b Ratio of the number of curricula in which bachelor's degrees were granted to students (classified by HEGIS subdivisions)

X_m Ratio of the number of curricula in which master's degrees were granted to students

X_d Ratio of the number of curricula in which doctoral degrees were granted to students

X_r Exponential function of the enrollment which correlated with the multiple regression residuals

X_e Ratio of instructional costs from Educational and General Funds to student enrollment

The variable X_r was derived when it was observed that the residuals of the plot of X_e on X_f, X_b, X_m, and X_d showed a curvilinear relationship with enrollment. Several curves were tried and an exponential was chosen as the best fit. When the new variable was entered into the regression, the multiple R^2 increased significantly. Of course, this produced a new set of residuals with a different curvature. So the exponential was refitted and another correlation run with another but smaller increase in R^2. Convergence was achieved in four cycles when the R^2 showed no variation in the eighth decimal place.

With the exception of X_r all the variables were divided by enrollment in order to relate enrollment as a function of residual cost. Obtaining this ratio converts the criterion to a per unit cost, a condition which is conceptually similar to what many state formula funding procedures consider in allocations. The formulas for the variables appear in Footnote 1.

Results

Two key concepts under review in this paper are the effects of economy of scale and complexity on costs. Both concepts are illustrated in Figures 1 and 2. The theory of economy of scale in higher education seemingly is supported by the results of a nonlinear regression of costs per student on enrollment, as shown in Figure 1. It is interesting to note that the greatest "savings" in efficiency occur between 2,500 and 7,500 students, well within the conclusions of the Carnegie report previously noted. Lest this curve create excessive excitement however, the size of an institution explains about 2.6% of the variation in its cost per student, statistically significant ($p<.01$) but of questionable importance. At the same time the complexity relationship between the number of HEGIS fields granting baccalaureates (a measure very closely related to the total number of HEGIS fields) and size of student body emerges in Figure 2. This relationship, also nonlinear, is much stronger than the implied economy of scale ($r=.816$). Therefore, while economy of scale influences student costs, complexity, as measured by curricular offerings, should be considered when investigating how costs per student might relate to size.

The five causal variables when analyzed through path analysis give the model depicted in Figure 3 ($R=.684$; $F=236$, $df=5, 1341$; $p<.001$). In this model all paths with a value less than 0.1 have been deleted. Tables 1 and 2, which accompany Figure 3, provide the associated figures.

Analysis of Figure 3 gives information on several issues. Increasing the relative number of faculty, according to the model, has a direct effect on the number of different degrees at all three levels: bachelor's (.350), master's (.098), and doctoral (.154). These effects, which are statistically significant and positive, suggest that the more faculty the more curricula. According to the model, increasing the number of faculty will cause more bachelor degree specialities and to some lesser extent more master's and doctoral specialities. The direct effect of bachelor's degree curricula on the residual enrollment function (.521), probably derives from a tendency of an institution to have a core of undergraduate specialities which increase as enrollment rises, but at a slower rate. (This same finding is illustrated in Figure 2.) The relative number of faculty has the largest direct effect on cost per student (.586); however, the doctoral degree, with the complexity it adds, has a direct effect of .214. Other variables which influence instructional expenditures per student have a value less than .10. The paths in Figure 3 give additional information about current structural relationships in higher education. For example, the relative number of bachelor curricula has a −.180 direct effect on X_m and a −.142 direct effect on X_d. The negative effects indicate that institutions which have more than the average number of bachelor's degrees tend to have fewer graduate degrees. Such a finding suggests a hypothesis for later study: if a department or institution is blocked from adding graduate degrees, it responds by increasing courses or specialities at the bachelor's level.

While the correlation is too small to appear in the simplified model in Figure 3, X_r has a direct effect of .072 on X_e. This effect is all the relationship that exists to show economy of scale to costs. The fact of the matter, therefore, is that economy of scale influences costs slightly but complexity influences them more.

Somewhat related to the minimal importance of size in explaining costs, is the fact that the enrollment function has a low relationship to the staffing ratio (explaining 6% of the variance); complexity at the baccalaureate level explains slightly over twice as much variance in X_f (12.3%). The use of all three measures of complexity (X_b, X_m, X_d) gives a multiple correlation of .389 and explains 15.1 percent of the variance in faculty per student. All this is to say that it is large numbers of curricula and associated complexity, not size alone, which makes for cost.

Analysis of Table 1

Data in Table 1 suggest that costs per student are significantly correlated to all the preceding variables used with values ranging from a high of .636 for faculty effect to a low of .169 for the enrollment function, X_r. The relationship of complexity to expense is also shown by the correlations of r_{be}=.218, r_{me}=.172, and r_{de}=.300. This later finding supports the contention of Blau (1974) that complexity is associated with the number of degrees offered. The influence of curricula complexity is illustrated by the fact that the direct effect of complexity increases as the degree level increases (.021, .082, and .206 for X_b, X_m, and X_d, respectively). This finding may be unique for this sample, but is worthy of further investigation.

Analysis of Table 2

In Table 2 it may be observed that approximately one faculty member is primarily engaged in instruction for every 20 students (3037 ÷ 152.2). Furthermore, over all institutions one finds a different degree field at the bachelor's level for every 121 students (3037 ÷ 25.07). The raw regression weights allow one to compute the effect of change in causal variables on resulting costs. Interpretation of these weights tends to be complex, because enrollment is used in the denominator. Using enrollment in the denominator appears more useful than an analysis based on variables not adjusted for size. Using unadjusted variables in this study, for example, resulted in a multiple correlation exceeding .96, with many correlations greater than .9. Such high relationships mask the relative effect of causal variables and contribute to computational problems.

Perhaps an example may illustrate this point. If an institution has 10,000 students, the addition of a degree will cause a shift of 1×10^{-4} in each measure of complexity (X_b, X_m, and X_d). For an institution of this size, the increases in costs per student would be .24, 3.34, and 25.31 dollars for bachelor's, master's, and doctoral degrees, respectively. Larger institutions can expect less of an increase in costs per student.

Conclusions

Based on results from a national sample of 1347 four-year universities which have an enrollment between 200 and 40,000 students and reported a sufficient amount of information on the 1975 HEGIS reports to be included in this study, several issues have emerged on what factors cause per capita student costs and how these factors relate to each other. An earlier researcher in this area, Blau (1974) suggested that complexity, not size, influenced student costs and contended that economies of scale would be erased by complexity. The path analysis of the model in this study reveals that size does have a direct effect on costs per students; however, the amount is small and is eclipsed by the far greater effect of changes in the staffing ratio and by changes in curricula complexity. This research, therefore, confirms the findings of Blau. This present study also finds the contention of Jordan (1965) and the Carnegie Commission of Higher Education (1972) that economies of scale cause per capita expenditures to decrease is correct in part, but cautions that these studies did not extend far enough to take into account the results of adding faculty and more curricula.

Many factors influence costs. The staffing ratio has the greatest direct effect on costs--not surprising since salaries represent about two-thirds to three-quarters of the educational and general costs of an institution. These staffing ratios, however, appear to be independent of other factors in the model, essentially resulting from external influences. Increasing the density of faculty has a direct effect on the relative number of different degrees at the bachelor's, master's, and doctor's level. Futhermore, if an institution or department is blocked from adding degrees at the graduate level, a tendency exists to proliferate undergraduate courses and curricula. The resulting complexity has a much larger effect on per student expenditure than does size.

Costs are associated with curricula. What, therefore, is the consequence of any movement to fund according to size, as suggested by the resolution of the Virginia House of Delegates? The complex institutions will be penalized, for they, as a result of their complexity, are unable to take advantage of the implied economies of scale. If changes in formula occur which advantage smaller or less complex institutions, and there is no intention by the authors to suggest this should or should not take place, the results on costs can be predicted: if better funding allows more faculty to be hired, pressures will quickly emerge to increase curricular offerings. As curricular offerings increase, costs rise. Costs for adding more degrees to a given institution in a state are relative, for it costs less to add a degree in a large institution than in a small one. This finding results from the fact that the variables in the model were standardized by dividing by the number of students--the larger the denominator the less the change caused by adding one to the numerator. Therefore, if a state wants to "save" money, it can do so by adding degrees to existing large institutions; it can also do so by adding enrollment at small or less complex institutions--<u>if</u> the number of curricula and degrees can be held constant. The need to restrict complexity of smaller institutions is especially important for graduate degrees. Holding curricula constant, however, is a condition which has seldom occured in the last 100 years in public education in the United States.

This research has provided a look into factors which influence student costs. The entire topic, however, needs much more investigation. Among the issues left unresolved or suggested for future study by this research are the following:

(1) How does cost of living in a geographical area influence per student costs?

(2) Does the curricular mix play a role? For example, if faculty in some disciplines receive more pay than in others, how should this affect the model?

(3) What will be the impact of steady-state or declining conditions and the resulting restrictions imposed by state agencies and by union contracts?

(4) How does quality influence costs?

Patterns for funding public colleges and universities have emerged over several decades. Those individuals who develop formula funding algorithms should give attention to these patterns. The consequences of such inattention to reality may advantage or disadvantage a given institution and cause a state to "save" or "lose" money, for per student costs are effectively masked in complexity and many factors contribute to per student costs. It is easy in formula funding to focus on the construct of size and disregard the important role of institutional complexity, not to mention quality. The consequences of such simplicity may advantage or disadvantage specific institutions, but in the long run it gives a misleading concept of institutions of higher education and is a disservice to all.

Footnote

1. Equations for the variables are as follows:

$$X_b = p_{bf}X_f$$

$$X_m = p_{mf}X_f + p_{mb}X_b$$

$$X_d = p_{df}X_f + p_{db}X_b + p_{dm}X_m$$

$$X_r = p_{rf}X_f + p_{rb}X_b + p_{rm}X_m + p_{rd}X_d$$

$$X_e = p_{ef}X_f + p_{eb}X_b + p_{em}X_m + p_{ed}X_d + p_{er}X_r$$

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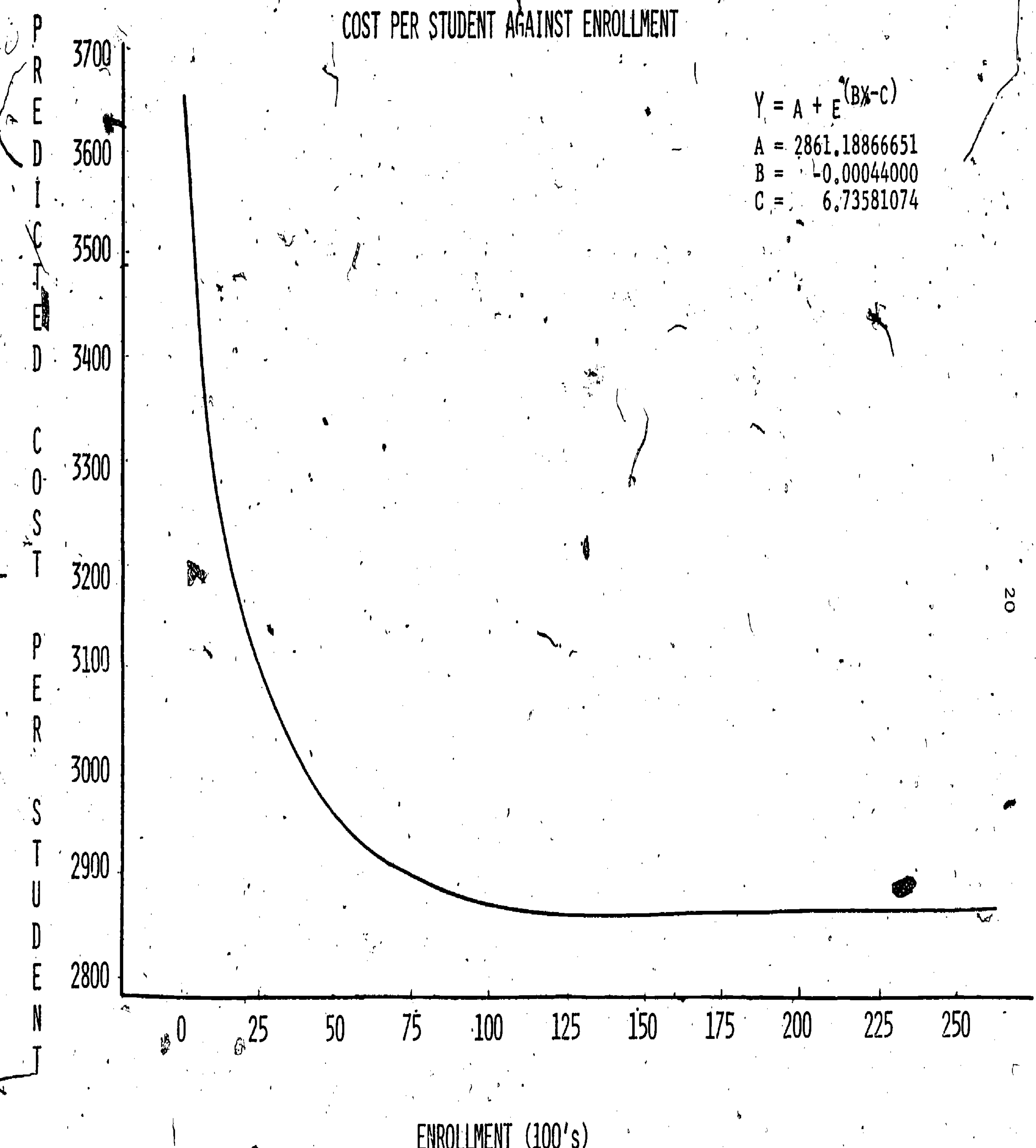
COST PER STUDENT AGAINST ENROLLMENT
Y = A + E^(BX-C)
A = 2861.18866651
B = -0.00044000
C = 6.73581074
PREDICTED COST PER STUDENT
3700
3600
3500
3400
3300
3200
3100
3000
2900
2800
0
25
50
75
100
125
150
175
200
225
250
ENROLLMENT (100's)

FIGURE 1

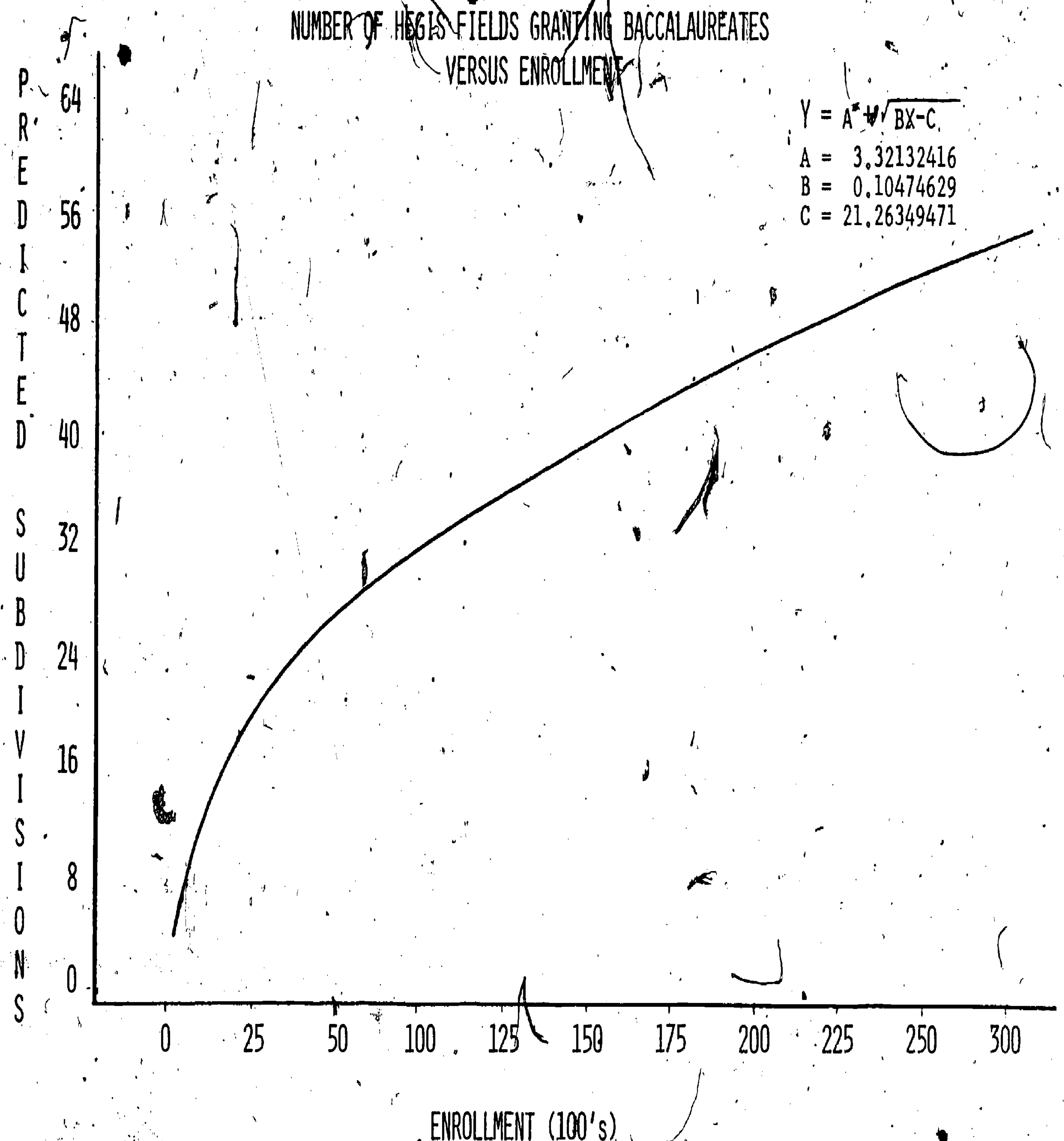
NUMBER OF HEGIS FIELDS GRANTING BACCALAUREATES
VERSUS ENROLLMENT
Y = A + √BX-C
A = 3.32132416
B = 0.10474629
C = 21.26349471
PREDICTED SUBDIVISIONS
64
56
48
40
32
24
16
8
0
0
25
50
100
125
150
175
200
225
250
300
ENROLLMENT (100's)

FIGURE 2

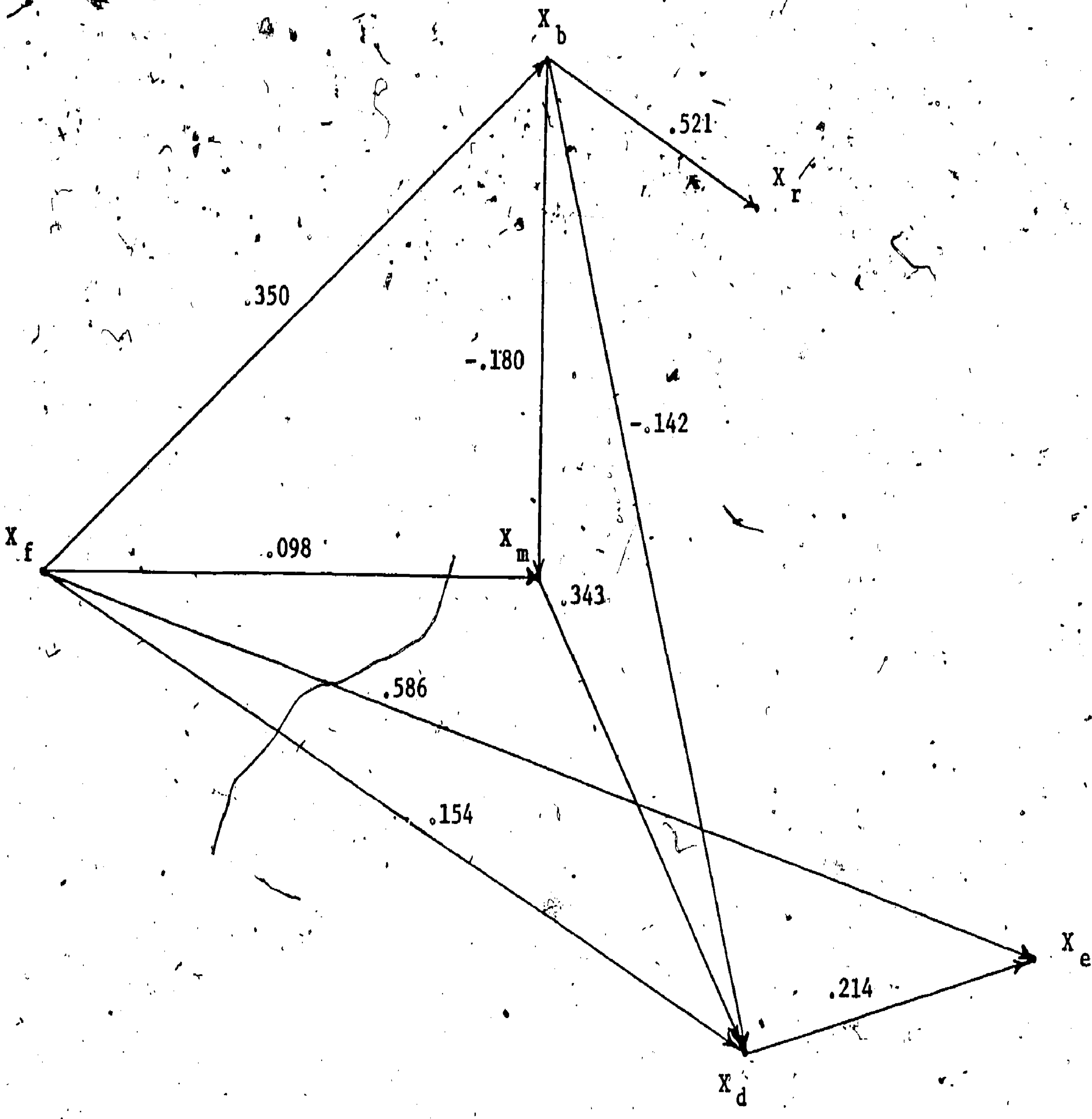

Figure 3

REDUCED PATH MODEL

Table 1

Structural Relationships for the Explanation of Cost Per Student

Effect/Association On	By	Association (Correlation)	Total Effect	Direct Effect
X_b	X_f	.350	.350	.350
X_m	X_f	.035	.035	.008
	X_b	-.145	-.180	-.180
X_d	X_f	.117	.117	.155
	X_b	-.138	-.204	-.142
	X_m	.369	.343	.343
X_r	X_f	.239	.239	.069
	X_b	.567	.551	.521
	X_m	-.180	-.105	-.078
	X_d	-.169	-.077	-.076
X_e	X_f	.637	.637	.586
	X_b	.218	-.005	.015
	X_m	.172	.153	.088
	X_d	.301	.209	.214
	X_r	.169	.072	.072

Table 2

Statistics for Measures

	Actual Mean	Per Student Mean	Per Student SD	Per Student Raw Regression Weights
Expenditures	9,263,736	3286	1418	
Faculty	152.2	.0156	.0124	41415.04
Bachelors	25.07	.0156	.0124	1667.79
Masters	8.23	.0020	.0037	33790.35
Doctorates	1.65	.00025	.00122	248917.2
Enrollment	3037	946.01*	111.84	.9186
(Constant)				-21.6853

* $X_r = 659.9 + \exp(-.0001915 \times \text{enrollment} + 6.064)$